Explaining the variability in cardiovascular risk factors among First Nations communities in Canada: a population-based study

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Summary

Background Historical, colonial, and racist policies continue to influence the health of Indigenous people, and they continue to have higher rates of chronic diseases and reduced life expectancy compared with non-Indigenous people. We determined factors accounting for variations in cardiovascular risk factors among First Nations communities in Canada.

Methods Men and women (n=1302) aged 18 years or older from eight First Nations communities participated in a population-based study. Questionnaires, physical measures, blood samples, MRI of preclinical vascular disease, and community audits were collected. In this cross-sectional analysis, the main outcome was the INTERHEART risk score, a measure of cardiovascular risk factor burden. A multivariable model was developed to explain the variations in INTERHEART risk score among communities. The secondary outcome was MRI-detected carotid wall volume, a measure of subclinical atherosclerosis.

Findings The mean INTERHEART risk score of all communities was 17·2 (SE 0·2), and more than 85% of individuals had a risk score in the moderate to high risk range. Subclinical atherosclerosis increased significantly across risk score categories (p<0·0001). Socioeconomic advantage (–1·4 score, 95% CI –2·5 to –0·3; p=0·01), trust between neighbours (–0·7, –1·2 to –0·3; p=0·003), higher education level (–1·9, –2·9 to –0·8, p<0·001), and higher social support (–1·1, –2·0 to –0·2; p=0·02) were independently associated with a lower INTERHEART risk score; difficulty accessing routine health care (2·2, 0·3 to 4·1, p=0·02), taking prescription medication (3·5, 2·8 to 4·3; p<0·001), and inability to afford prescription medications (1·5, 0·5 to 2·6; p=0·003) were associated with a higher INTERHEART risk score. Collectively, these factors explained 28% variation in the cardiac risk score among communities. Communities with higher socioeconomic advantage and greater trust, and individuals with higher education and social support, had a lower INTERHEART risk score. Communities with difficulty accessing health care, and individuals taking or unable to afford prescription medications, had a higher INTERHEART risk score.

Interpretation Cardiac risk factors are lower in communities with high socioeconomic advantage, greater trust, social support and educational opportunities, and higher where it is difficult to access health care or afford prescription medications. Strategies to optimise the protective factors and reduce barriers to health care in First Nations communities might contribute to improved health and wellbeing.

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Introduction

First Nations people living in Canada have higher rates of chronic diseases and have reduced life expectancy than non-Indigenous people.[1–4] No other population in Canada experiences worse overall health outcomes.[3,4] For example, compared with non-Indigenous people, the age-standardised cardiovascular disease mortality is 30% higher for First Nations men and 76% higher for First Nations women.[2] In our understanding of the health status of First Nations peoples and plans for solutions, the recognition of the effect of sociopolitical factors as a central determinant of health in this group is essential. European colonisation in Canada dismantled the sociopolitical, economic, cultural, educational, and healthful structures and practices of First Nations peoples.[5,6] Today's health status of First Nations people in Canada reflects these powerful forces. Distal (colonialism, racism, and self-determination), intermediate (health systems, infrastructure, and resources), and proximal (employment, income, education, and health behaviours) determinants of health are the underlying conditions affecting First Nations health.[7–9]

Through partnerships formed between academic researchers and eight First Nations communities in

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See **Online** for appendix

For more on the **communities** see https://cahhm.mcmaster.ca/?page_id=6113

Research in context

Evidence before this study

The burden of cardiovascular risk factors is higher among Indigenous peoples of North America, Australia, New Zealand and the USA compared with non-Indigenous peoples. This increased burden probably reflects the effects of colonisation and government policies that led to worse socioeconomic circumstances and a shift away from many traditional practices and ways of knowing of Indigenous peoples. In Canada, previous work indicates the powerful effect of social disadvantage on the presence of cardiovascular risk factors and cardiovascular disease, especially among Indigenous men and women. Most comparisons have focused on the health inequity between Indigenous and non-Indigenous peoples; however no previous study has examined what factors make the cardiovascular risk factor burden of some First Nations communities lower and others higher, when communities are compared.

Added value of this study

Understanding protective and risk factors for cardiovascular health can help local First Nations communities and governments develop short-term and long-term policies to improve their risk factor burden. From our research, short-term factors that could be changed include increasing access to primary care services, prescription medications, and post-secondary educational opportunities, whereas other factors such as social and economic prosperity will take longer, but should be part of First Nations-led long-term economic strategies on their path to self-determination.

Implications of all the available evidence

Positive features of healthy communities should be fostered, including trust and social support, whereas structural changes, including increasing educational opportunities, greater access to primary care and prescription medications are needed.

Canada, we developed a national cohort study.[10] Our primary goal was to further understand the causes of the causes of chronic diseases experienced by First Nations people in Canada. We hypothesised that communities with greater social advantage would have a lower cardiovascular risk factor burden. Specifically, in this cross-sectional analysis we sought to determine the burden of cardiovascular risk factors in eight First Nations communities, and assess the influence of community and individual-level factors and access to health services to understand the variation in risk factor burden between communities. Using the same research protocol (thereby standardising the information collected across eight diverse communities), this Canadian Alliance for Healthy Hearts and Minds (CAHHM) First Nations (CAHHM-FN) study is positioned to ask this question, with the hope that modifiable factors to improve the health of communities can be identified.

Methods

Study design and participants

The detailed methods of the CAHHM study have been previously published.[10] The First Nations cohort study used a similar protocol of health questionnaires, physical measurements, and MRI as used by the non-Indigenous cohort study reported separately.[11]

Briefly, First Nations people aged 18 years or older who lived on or in close proximity to eight communities (ranging from communities in close proximity to an urban centre to rural remote communities) across Canada voluntarily participated in this study. At the outset of the study, ethical approval for CAHHM was obtained by the Hamilton Integrated research ethics board in October, 2013, and for each participating First Nations community or regional research ethics board (where such were available), and by the respective academic institutions of the local lead investigators. Details of recruitment which took place between Dec 4, 2013, to June 29, 2018, have been previously described.[10] Briefly, men and women were approached for participation in the study by a community member working on behalf of the research study. Methods to increase awareness and facilitate recruitment included radio shows, posters, word of mouth, and newspaper advertisements. A list of investigators and community advisory committees is provided in the appendix (p 6).

Participants completed a detailed assessment of their health behaviours, local home and workplace environments, social supports, and health services access and use by completing questionnaires. Physical measures included weight, height, waist-to-hip ratio, and blood pressure. Where possible, a blood sample and MRI scan or carotid ultrasound (in one remote community) was done to assess the presence of atherosclerosis of the carotid arteries (appendix p 1).

The non-laboratory based INTERHEART risk score (IHRS) was calculated to quantify the cardiovascular risk factor burden,[12] and in a subset of participants in whom blood collection was possible, the laboratory-based IHRS (which includes apolipoproteins B and A-1) was calculated. The IHRS is a validated and robust individual-level measure of cardiovascular risk and is validated as a predictor of myocardial infarction and cardiovascular disease.[12,13] The IHRS has also been used as a measure of risk to direct therapeutic interventions such as use of cholesterol and blood pressure lowering medications.[14] The non-Indigenous cohort of CAHHM reported that the IHRS is significantly associated with carotid atherosclerosis and cerebrovascular disease.[15] The non-laboratory based IHRS was calculated for everyone, and included information on age, sex, smoking status, exposure to second-hand smoke, diabetes, high blood

	n	Overall	Community A	Community B	Community C	Community D	Community E	Community F	Community G	Community H
n	1302	1302	188	107	180	190	209	199	135	94
Age, years (mean [SD])*	1302	45·5 (13·4)	48·6 (12·0)	44·2 (14·2)	49·1 (12·4)	48·2 (10·0)	43·0 (15·5)	40·9 (13·0)	49·4 (12·2)	38·6 (13·2)
Sex*, n=1301										
Female	..	860 (66·1%)	115 (61·2%)	76 (71·0%)	141 (78·3%)	128 (67·4%)	124 (59·3%)	121 (60·8%)	93 (69·4%)	62 (66·0%)
Male	..	441 (33·9%)	73 (38·8%)	31 (29·0%)	39 (21·7%)	62 (32·6%)	85 (40·7%)	78 (39·2%)	41 (30·6%)	32 (34·0%)
Family history of myocardial infarction*	1271	368 (26·4%)	63 (30·9%)	23 (20·2%)	53 (23·2%)	57 (25·6%)	39 (18·4%)	50 (27·1%)	52 (32·4%)	31 (38·9%)
Elevated cholesterol*	1259	334 (22·3%)	57 (24·0%)	26 (22·4%)	52 (23·5%)	59 (25·4%)	23 (8·0%)	45 (24·7%)	53 (30·4%)	19 (25·8%)
Self-reported history of diabetes*	1272	198 (12·9%)	14 (5·4%)	12 (9·7%)	30 (11·7%)	45 (19·3%)	9 (3·5%)	24 (12·6%)	51 (31·0%)	13 (16·6%)
Hypertension*	1272	538 (43·8%)	52 (24·9%)	36 (37·0%)	64 (32·2%)	89 (45·3%)	90 (49·5%)	92 (54·8%)	76 (54·7%)	39 (54·5%)
Blood pressure, mm Hg*										
Systolic (mean [SE])	1269	130 (0)	124 (1)	126 (2)	126 (1)	131 (1)	134 (1)	135 (1)	130 (1)	132 (2)
Diastolic (mean [SE])	1270	81 (0)	77 (1)	76 (1)	77 (1)	84 (1)	85 (1)	84 (1)	82 (1)	83 (1)
Smoking status*, n=1271										
Current (in past year)	..	584 (46·5%)	28 (16·9%)	64 (61·1%)	49 (28·8%)	112 (60·8%)	86 (42·5%)	144 (71·4%)	54 (42·5%)	47 (48·3%)
Former (quit >1 year ago)	..	374 (27·8%)	65 (34·2%)	25 (23·1%)	62 (30·3%)	50 (23·8%)	64 (32·5%)	31 (16·5%)	51 (34·2%)	26 (31·0%)
Never smoked	..	313 (24·7%)	80 (47·8%)	16 (14·9%)	69 (40·1%)	27 (14·9%)	49 (23·8%)	24 (11·2%)	28 (22·1%)	20 (19·7%)
Second hand smoke exposure* (≥1 h/week)	1271	549 (43·6%)	31 (18·5%)	51 (49·0%)	57 (33·0%)	108 (58·2%)	68 (34·0%)	116 (57·8%)	50 (38·8%)	68 (72·6%)
Abdominal obesity* (WHR†)	1268	996 (80·5%)	127 (67·6%)	75 (75·2%)	145 (81·7%)	160 (88·4%)	146 (80·1%)	143 (76·6%)	123 (92·7%)	77 (87·3%)
Leisure physical inactivity*	1270	834 (63·8%)	79 (43·2%)	75 (69·3%)	115 (59·7%)	122 (61·7%)	137 (68·7%)	140 (69·9%)	97 (71·1%)	69 (73·6%)
Eat salty foods or snacks one or more times a day*	1272	814 (64·0%)	62 (36·7%)	79 (74·7%)	112 (63·1%)	134 (71·6%)	132 (65·6%)	144 (70·9%)	75 (57·6%)	76 (80·0%)
Eat deep fried foods or snacks or fast foods three or more times a week*	1272	578 (46·7%)	23 (14·2%)	41 (40·3%)	82 (49·7%)	105 (58·4%)	97 (48·7%)	104 (51·6%)	59 (46·9%)	67 (71·5%)
Eat less than one serving of fruit a day*	1272	344 (28·3%)	38 (23·2%)	18 (18·1%)	50 (30·9%)	38 (21·5%)	61 (30·8%)	60 (30·2%)	47 (37·9%)	32 (34·5%)
Eat less than one serving of vegetables a day*	1272	266 (21·6%)	20 (12·5%)	13 (12·7%)	41 (26·4%)	37 (21·4%)	38 (18·3%)	46 (22·0%)	46 (37·5%)	25 (25·1%)
Eat meat, or poultry, or both two or more times a day*	1272	832 (65·9%)	79 (46·5%)	76 (72·2%)	102 (57·7%)	139 (74·2%)	152 (76·1%)	150 (74·7%)	64 (49·2%)	70 (74·1%)
Depression*	1272	570 (42·0%)	54 (29·5%)	54 (47·0%)	53 (25·7%)	101 (51·1%)	107 (51·6%)	82 (37·6%)	55 (38·1%)	64 (64·9%)
Home or work stress*	1272	544 (38·8%)	67 (36·5%)	42 (34·3%)	77 (37·5%)	95 (47·2%)	86 (40·0%)	62 (26·7%)	58 (39·7%)	57 (55·7%)
Poor diet quality	1272	789 (63·6%)	47 (29·0%)	72 (69·7%)	102 (60·8%)	136 (74·4%)	139 (70·0%)	146 (72·6%)	68 (54·7%)	79 (84·3%)
No alcohol intake	1235	111 (7·5%)	8 (3·7%)	6 (4·8%)	11 (5·1%)	24 (10·7%)	26 (11·9%)	9 (4·4%)	22 (13·2%)	5 (5·3%)
Daily alcohol	1239	33 (2·6%)	11 (5·7%)	2 (2·0%)	0 (0·0%)	7 (3·7%)	6 (2·9%)	2 (1·0%)	3 (2·2%)	2 (2·7%)
Binge drinking, one or more per month	1179	482 (43·9%)	69 (45·8%)	46 (47·7%)	44 (36·3%)	50 (33·4%)	72 (39·2%)	111 (59·4%)	36 (34·7%)	54 (56·6%)
Apolipoprotein B (mean [SE])	1060	0·94 (0·01)	0·99 (0·02)	0·95 (0·02)	0·95 (0·02)	0·91 (0·02)	0·89 (0·02)	0·92 (0·02)	0·97 (0·03)	0·94 (0·03)
Apolipoprotein A (mean [SE])	1060	1·44 (0·01)	1·54 (0·02)	1·46 (0·03)	1·37 (0·02)	1·40 (0·02)	1·46 (0·02)	1·46 (0·02)	1·34 (0·03)	1·45 (0·03)
Apolipoprotein B:A (mean [SE])	1059	0·67 (0·01)	0·66 (0·02)	0·67 (0·02)	0·71 (0·02)	0·68 (0·02)	0·63 (0·02)	0·65 (0·02)	0·73 (0·02)	0·66 (0·03)
High school education or higher	1244	1062 (85·2%)	167 (97·2%)	83 (78·7%)	146 (93·7%)	159 (86·1%)	177 (87·4%)	147 (73·4%)	111 (83·8%)	72 (76·3%)
Married or common law	1244	645 (51·8%)	121 (69·6%)	57 (54·6%)	86 (54·2%)	94 (49·9%)	114 (56·8%)	94 (48·4%)	47 (34·7%)	32 (35·6%)
Employed or retired	1240	781 (62·9%)	165 (95·8%)	80 (78·5%)	135 (85·4%)	104 (51·9%)	103 (53·9%)	77 (42·3%)	66 (44·5%)	51 (62·1%)
Social disadvantage score‡ (mean [SE])	981	2·4 (0·1)	1·3 (0·1)	1·8 (0·2)	1·9 (0·1)	2·5 (0·1)	2·8 (0·1)	3·1 (0·1)	3·2 (0·2)	3·3 (0·2)
High social disadvantage	981	296 (31·0%)	9 (5·8%)	12 (16·4%)	20 (14·3%)	35 (27·8%)	63 (43·0%)	76 (49·7%)	52 (51·1%)	29 (44·9%)

(Table 1 continues on next page)

	n	Overall	Community A	Community B	Community C	Community D	Community E	Community F	Community G	Community H
(Continued from previous page)										
Prevalent atherosclerotic cardiovascular disease	1259	45 (2·5%)	5 (1·5%)	3 (2·1%)	5 (1·8%)	8 (2·9%)	10 (3·2%)	8 (3·5%)	4 (1·7%)	2 (2·6%)
Non-laboratory IHRS (mean [SE])	1248	17·2 (0·2)	12·2 (0·5)	16·9 (0·6)	14·9 (0·5)	19·2 (0·5)	16·7 (0·5)	18·8 (0·5)	19·7 (0·6)	21·3 (0·7)
Full-laboratory IHRS (mean [SE])	1026	16·5 (0·2)	11·9 (0·5)	16·8 (0·6)	15·1 (0·5)	18·8 (0·5)	15·8 (0·6)	18·3 (0·5)	18·4 (0·7)	19·8 (0·8)
Carotid vessel wall volume, mm³	746	905·5 (6·4)	887·5 (12·2)	899·4 (18·7)	852·3 (14·8)	921·5 (13·2)	917·8 (17·2)	NA§	912·7 (18·6)	998·6 (20·9)

Data are mean (SD), n (%) adjusted for age and sex, or adjusted mean (SE). Age and sex are not adjusted. IHRS=INTERHEART risk score. WHR=waist-to-hip ratio. *Component factors of the IHRS. †Abdominal obesity is defined for women as WHR of more than 0·85 and for men as a WHR of more than 0·90. ‡Social disadvantage score was calculated by income less than CAN$25 000 per year assigned a score of two, income between $25 000 and 75 000 per year a score of one, unemployment (including retirement) was assigned a score of two, and living without a partner was assigned a score of one. The maximum social disadvantage score was five, and the lowest possible score was zero, reflecting the least social disadvantage. §Community used carotid B-mode ultrasound mean maximum intimal medial thickness 0·73 (SD 0·27).

Table 1: **Demographic and IHRS characteristics, adjusted for age and sex**

pressure, family history of myocardial infarction, waist-to-hip ratio, home or work stress, depression, simple dietary questions, and physical activity. Scores ranged from zero to 48, with higher scores indicating a greater risk factor burden. The questions and scoring system are given in the appendix (p 9). Score summary reports were provided to each participant, and a description of each risk factor accompanied the report. In the majority of cases, the report was reviewed with participants by the research coordinator.

Procedures

Participants who did not have a contraindication to MRI, and for whom MRI was available, a short non-contrast enhanced scan using a 1·5 Tesla or 3 Tesla magnet was done. The MRI protocol was previously published,[11] and the key secondary outcome for this analysis is the carotid wall volume—a continuous measure of atherosclerosis.

Outcomes

A community audit of access to and availability of foods, tobacco, and physical activity (including walkability of the community[16]) was completed by a trained auditor who was familiar with the community. Auditors used a standardised instrument to collect objective measures of community demographics: accessibility by bus, rail, or car; availability and prices of tobacco products; and of healthy and unhealthy foods in grocery stores and restaurants; prices of alcohol (ie, beer and wine); and availability of traditional foods (ie, wild game and plants). A digital profile of each community can be found online, and is similar to that developed for the non-Indigenous cohort.[16]

For more on the **community profiles** see http://cvcdcontextual.mcmaster.ca/fn

Statistical analysis

Raw counts with proportions adjusted for age and sex, or adjusted means (SE), are provided for baseline characteristics and the IHRS to make risk factor proportions among communities more comparable in this cross-sectional analysis. Because the IHRS was developed to predict atherosclerotic cardiovascular disease, participants with a history of atherosclerotic cardiovascular disease were not included in the comparison of risk factor variation among the communities. To examine the variation of the IHRS among the communities, we used PROC GLIMMIX (REML) to build linear mixed models with random intercepts for community, using an unstructured covariance matrix. The random community intercepts allowed for the calculation of the variance partitioning coefficient (VPC), which is the proportion of the residual total variance that is accounted for by community mean differences. For the modelling, to explain differences among communities, a number of individually collected factors were assigned the mean (or median) level of the community. This decision was based on the literature and guided by each factors' VPC, where factors that were collected at the individual level but that exhibited little variation among members of the communities, while having high variability between communities (VPC >0·10), were used to account for community-level variation. To construct our model, we first considered the variability accounted for in the univariate models for each community-level variable with the IHRS. Any variable (community or individual level) with $p<0·10$, after a check for collinearity, was considered in the multivariable model. The final multivariable model was based on a manual forward selection that included clinically and statistically significant variables, with the addition of age and sex. Normality assumptions were met for the IHRS. Finally, each factor from the final multivariable model was tested in a mixed model with our secondary outcome (carotid wall volume adjusted for IHRS, age, and sex), and holding centre as a random effect. All analyses were done using SAS version 9.4 (SAS Institute Inc, Cary, NC, USA).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to

	n	Overall	Community A	Community B	Community C	Community D	Community E	Community F	Community G	Community H
Recruited	1302	1302	188	107	180	190	209	199	135	94
High optimism about future of your community	1249	597 (48·5%)	150 (87·0%)	56 (54·4%)	79 (54·1%)	80 (44·0%)	48 (23·4%)	76 (38·1%)	61 (48·6%)	47 (50·1%)
Neighbours work together	1231	585 (48·4%)	110 (62·7%)	48 (47·4%)	73 (47·1%)	60 (31·9%)	97 (50·7%)	88 (47·2%)	53 (40·9%)	56 (64·4%)
Neighbours help each other	1230	825 (67·4%)	137 (78·6%)	75 (72·2%)	118 (76·7%)	90 (48·4%)	134 (69·0%)	126 (65·7%)	74 (58·1%)	71 (77·6%)
Trust your neighbours	1227	598 (49·6%)	149 (85·8%)	36 (35·3%)	79 (52·1%)	46 (25·2%)	102 (52·5%)	88 (46·5%)	51 (40·8%)	47 (52·7%)
High affinity to heritage culture	1192	646 (53·1%)	70 (38·5%)	72 (68·2%)	88 (54·3%)	117 (60·6%)	99 (50·1%)	81 (56·2%)	69 (48·9%)	50 (55·1%)
Concerned that community members are exposed to racism	1255	486 (37·4%)	61 (33·7%)	53 (48·3%)	78 (48·0%)	80 (40·5%)	69 (33·4%)	56 (28·2%)	33 (22·6%)	56 (60·3%)
Easy access to tobacco	1232	558 (46·9%)	50 (29·8%)	38 (38·4%)	87 (60·8%)	88 (50·9%)	94 (48·4%)	95 (49·5%)	71 (56·5%)	35 (38·9%)
Greater than 75% of life in your community	1214	691 (57·8%)	84 (51·4%)	45 (43·5%)	112 (75·6%)	119 (68·4%)	100 (51·9%)	118 (60·2%)	55 (46·1%)	58 (61·0%)
Close relationship with five or more family members	1193	957 (79·6%)	145 (83·0%)	83 (80·1%)	129 (83·4%)	128 (73·0%)	138 (76·4%)	161 (82·5%)	98 (78·2%)	75 (81·2%)
Screen time at least 2 h/day	1209	625 (51·0%)	105 (61·8%)	37 (33·6%)	100 (67·1%)	92 (50·8%)	81 (41·5%)	89 (43·7%)	55 (45·4%)	66 (69·6%)

Data are n (%), adjusted for age and sex.

Table 2: **Sociocultural factors, adjusted for age and sex**

all the data in the study and had final responsibility for the decision to submit for publication.

Results

1302 women and men from eight distinct First Nations communities, each with their unique culture and history, participated in CAHHM-FN between Dec 4, 2013, and June 29, 2018. Communities spanned eastern, central, and western Canada, and urban and northern communities. The mean age of participants was 45·5 years (SD 13·4) and 860 (66·1%) of 1301 were women (table 1). 1062 (85·2%) of 1244 participants had completed high school education or a higher level of education. One-third of participants had high social disadvantage,[7] as determined by income, employment, and marital status.

The number of people who reported a history of atherosclerotic cardiovascular disease was low, at 45 (2·5%) of 1259. Overall, the mean non-laboratory-based risk score was 17·2 (SE 0·2), with the lowest community score being 12·2 (0·5) and the highest being 21·3 (0·7). Of those with no history of cardiovascular disease, 647 (54·7%) of 1183 participants' risk scores were classified as high risk, defined as a mean score of at least 16. The laboratory-based risk score analysed in 1026 participants had a mean of 16·5 (0·2) with the lowest community score being 11·9 (0·5) and highest being 19·8 (0·8). The non-laboratory-based and laboratory-based score were highly correlated with each other (r=0·93, p<0·0001). The individual components of the risk score by frequency are shown in table 1. The average IHRS for each community was strongly correlated with the mean social disadvantage index for the community (r=0·81, p=0·01 non-laboratory), meaning the greater the burden of socioeconomic hardship, the greater the burden of cardiovascular risk factors for a given community (table 1).

691 (57·8%) of 1214 participants had lived more than 75% of their lives in their community, and more than half of participants reported having a high affinity to their heritage culture (table 2). Almost half of the participants reported having high optimism for the future of their community, and 486 (37·4%) of 1255 reported being concerned about community members being exposed to racism when they travelled off the reserve. Almost half of the participants reported that neighbours in the community work together and trust each other, and more than two-thirds reported that neighbours help each other. Family support was high, because 957 (79·6%) of 1193 participants reported having a close relationship with five or more family members.

Briefly, 361 (28·7%) of 1259 participants reported not having a regular primary care provider, 529 (42·1%) of 1258 visited the emergency department at least once in the past year, and 297 (22·4%) of 1258 reported difficulties in getting routine or ongoing health care (table 3). 614 (45·9%) of 1255 of the study population reported currently taking a prescription medication, with more than two-thirds taking their medications regularly, and 181 (13·5%) of 1251 reported not filling prescriptions due to cost. From a cardiovascular prevention standpoint, 313 (20·6%) of 1227 were taking a blood pressure lowering medication, 172 (8·8%) of 1257 participants had been prescribed a statin, and 155 (7·9%) of 1257 reported taking aspirin daily. Although 469 (37·4%) of 1250 participants had previously had an electrocardiogram, previous testing with higher technology modalities such as echocardiography (137 [9·7%] of 1250) and cardiac MRI (75 [5·7%] of 1250) was much lower.

Among participants without known clinical atherosclerotic cardiovascular disease, 1001 (84·6%) of

	n	Overall	Community A	Community B	Community C	Community D	Community E	Community F	Community G	Community H
Recruited	1302	1302	188	107	180	190	209	199	135	94
Has a regular primary care provider	1259	898 (70·4%)	154 (87·4%)	64 (58·6%)	160 (100%)	145 (74·5%)	133 (66·3%)	38 (18·4%)	119 (87·1%)	85 (92·6%)
Visited emergency department in the past year	1258	529 (42·1%)	49 (28·4%)	39 (36·6%)	39 (24·5%)	106 (56·9%)	113 (54·6%)	84 (41·3%)	47 (35·7%)	52 (54·0%)
Difficulties getting routine or ongoing care	1258	297 (22·4%)	36 (19·7%)	22 (19·4%)	27 (15·1%)	52 (26·4%)	48 (22·5%)	54 (26·1%)	28 (19·7%)	30 (30·3%)
Recommended to increase physical activity	1262	531 (40·2%)	76 (40·7%)	30 (26·6%)	80 (45·2%)	85 (42·3%)	69 (33·5%)	71 (36·6%)	79 (55·2%)	41 (45·3%)
Recommended to lose weight	1262	401 (30·1%)	51 (26·9%)	29 (25·9%)	65 (36·5%)	64 (31·6%)	46 (22·2%)	54 (27·8%)	59 (41·0%)	33 (36·5%)
Recommended to quit smoking	1262	358 (28·0%)	25 (13·5%)	24 (21·8%)	20 (11·4%)	70 (35·7%)	58 (28·1%)	87 (44·2%)	44 (31·3%)	30 (32·5%)
Recommended to reduce stress	1262	278 (19·1%)	40 (20·6%)	18 (13·9%)	43 (22·0%)	46 (21·4%)	40 (17·5%)	37 (16·4%)	30 (19·5%)	24 (22·1%)
Recommended to change diet or eating habits, or both	1262	496 (37·4%)	54 (28·6%)	39 (35·2%)	84 (48·3%)	83 (41·5%)	52 (25·1%)	68 (35·0%)	75 (52·4%)	41 (45·2%)
Recommended to increase fruit or vegetable intake, or both	352	227 (64·6%)	28 (59·3%)	17 (71·6%)	44 (64·9%)	35 (62·7%)	18 (60·4%)	25 (65·2%)	45 (76·0%)	15 (54·1%)
Ever had any cardiac test	1250	609 (46·9%)	109 (57·8%)	54 (52·4%)	103 (57·7%)	84 (39·7%)	89 (45·7%)	73 (40·8%)	56 (34·2%)	41 (52·6%)
Ever had an electrocardiogram	1250	469 (34·7%)	91 (46·7%)	45 (42·3%)	82 (43·5%)	68 (31·6%)	67 (32·9%)	50 (27·0%)	36 (20·8%)	30 (37·4%)
Ever had an echocardiogram	1250	137 (9·7%)	36 (17·3%)	10 (8·8%)	22 (10·7%)	9 (4·0%)	18 (8·3%)	10 (5·3%)	18 (10·9%)	14 (17·1%)
Ever had a cardiac MRI	1250	75 (5·7%)	9 (3·9%)	7 (6·6%)	8 (4·2%)	13 (6·2%)	11 (4·9%)	10 (5·3%)	7 (4·3%)	10 (14·0%)
Currently taking prescribed medication	1255	614 (45·9%)	96 (49·3%)	56 (52·9%)	105 (58·6%)	82 (38·0%)	70 (33·5%)	75 (40·4%)	78 (51·0%)	52 (62·4%)
Always adheres to current medication as prescribed	629	428 (68·5%)	89 (91·9%)	38 (68·3%)	71 (67·6%)	50 (51·8%)	59 (83·8%)	39 (55·0%)	47 (59·4%)	35 (70·9%)
Taking a statin medicine	1257	172 (8·8%)	40 (13·1%)	12 (7·4%)	27 (8·7%)	31 (10·6%)	8 (1·8%)	19 (8·1%)	29 (12·0%)	6 (6·7%)
Taking aspirin	1257	155 (7·9%)	25 (7·1%)	14 (9·2%)	20 (6·1%)	30 (10·3%)	17 (4·4%)	23 (10·2%)	21 (8·1%)	5 (5·5%)
Taking a blood pressure lowering medication	1227	313 (20·6%)	42 (15·9%)	32 (28·7%)	44 (17·7%)	52 (21·7%)	40 (16·5%)	39 (21·4%)	42 (21·6%)	22 (29·8%)
Did not fill prescription because of cost	1251	181 (13·5%)	15 (7·9%)	15 (13·1%)	10 (5·4%)	48 (24·1%)	26 (12·2%)	20 (9·7%)	25 (17·4%)	22 (22·9%)
Saw doctor or nurse within 1 day last time they were sick	1256	616 (49·3%)	86 (49·2%)	52 (49·8%)	57 (35·5%)	101 (54·2%)	81 (39·8%)	143 (72·3%)	62 (45·6%)	34 (37·2%)
Recent screening for high blood pressure	1256	1107 (89·4%)	170 (97·6%)	89 (86·6%)	154 (95·5%)	155 (81·4%)	168 (86·4%)	154 (82·4%)	130 (96·9%)	87 (95·5%)
Recent screening for high cholesterol	1254	646 (51·1%)	135 (76·3%)	51 (51·3%)	108 (63·9%)	87 (41·9%)	74 (37·0%)	54 (30·1%)	82 (55·9%)	55 (71·5%)
Recent screening for diabetes	1254	768 (60·2%)	132 (73·1%)	55 (51·9%)	120 (70·0%)	116 (58·3%)	95 (47·8%)	91 (49·4%)	98 (69·5%)	61 (71·9%)

Data are n (%), adjusted for age and sex.

Table 3: **Health care access and use, adjusted for age and sex**

	No history of cardiovascular disease				History of cardiovascular disease
	Overall	Low IHRS (0–9)	Moderate IHRS (10–15)	High IHRS (16–48)	
Number per group	701	137	216	348	19
Non-laboratory IHRS	15·9 (7·0)	6·7 (1·9)	12·5 (1·8)	21·8 (4·5)	22·8 (8·4)
CWV*, mm^3	877·4 (178·3)	826·5 (166·6)	865·4 (167·4)	904·8 (184·4)	934·4 (167·4)

Data are n or mean (SD). 720 participants had a complete IHRS and an MRI CWV measurement, and 19 had a history of cardiovascular disease. IHRS=INTERHEART risk score. CWV=carotid wall volume. *p_{trend}<0·0001 for CWV in people with no history of atherosclerotic cardiovascular disease, calculated using linear contrasts across low, moderate, and high IHRS groups.

Table 4: **CWV and cardiac risk score by atherosclerotic cardiovascular disease history**

	Community A	Community B	Community C	Community D	Community E	Community F	Community G	Community H
Safe walking community (n=1228)	71%	15%	18%	16%	40%	34%	18%	51%
Percentage of top 10 nationally available fruits are available on reserve	0%	0%	40%	80%	70%	80%	40%	0%
Percentage of top 10 nationally available vegetables are available on reserve	0%	0%	40%	80%	70%	80%	40%	0%
Affordability of fruits and vegetables on reserve (ratio)*	0·81	1·36	0·94	1·23	1·79	2·00	0·91	1·76
Affordability of fruits and vegetables off reserve (ratio)*	0·53	0·89	0·62	0·76	1·17	1·41	0·64	1·16
Median time to drive by car to a grocery store, min (n=1032)	10	50	20	20	15	10	25	20
Distance (km) from reserve to centre with hospital	17·4	62·8	19·4	16·9	75·1	5–90	30·3	169·0

Factors were collected from community audits except for safe walking and time to drive to a grocery store, which are summarised from individual responses. Safe walking community shows the percent of community members who, on average, answered in a positive agreement to eight questions about safety and walking conditions within a 10–15 min walk from their home. Median driving time to a grocery store was restricted to those with a car. *Affordability is a ratio of prices from the First Nations audit to the national average price for a specified set of fruits and vegetables from the off-reserve provincial communities. 0·80 can be interpreted as spending 80% as much on fruits and vegetables as the national average, and 2·00 as pending twice as much as the national average.

Table 5: **Contextual factors**

1183 participants were classified as having moderate or high IHRS (ie, score >9). The burden of subclinical vascular disease as measured by the MRI carotid wall volume increased with increasing risk factor burden across risk score categories (p=0·0001; table 4).

The number of participants who indicated that their local community was safe and walkable ranged from 16 (15%) of 105 to 123 (71%) of 174; table 5). 558 (45%) of 1232 reported there was easy access to tobacco, and one community had an alcohol outlet on reserve. Grocery stores (located on reserve in seven communities) carried a reduced variety of foods including fruits, vegetables, meats, and dairy (13 [49%] of 26 total food list) compared with higher availability (23 [88%] of 26) foods located in grocery stores in neighbouring communities. Furthermore, all foods located both on and off reserve were more expensive on reserve, with the exception of milk. All communities reported access to at least one traditional method of hunting or gathering foods (such as wild game, fish, or vegetables like Indian white corn) or a store that sold native foods. The frequency of regular consumption of traditional foods was low, from 173 (15%) of 1136 consuming Indian corn soup to 398 (35%) of 1136 consuming hunted meat or wild game at least once per month.

Each community-level and individual-level factor was considered for its effect on the IHRS. As shown in the appendix (p 3), 14% of the residual variance was due to differences among centres that allowed us to explore the reasons for community differences. Of all the community-level factors considered, social advantage, trusting neighbours, access to routine health care, and cardiac tests helped to explain the IHRS differences among communities (ie, each variable reduced the VPC, coinciding with p<0·10; appendix p 3). Along with these community factors, individual factors with p<0·10 were then put into a multivariable model. Difficulty getting routine health care was chosen over community percentage with past cardiac test due to colinearity. In addition to age and sex, the following factors were independently associated with a lower risk factor burden: higher socioeconomic advantage (–1·4 score, 95% CI –2·5 to –0·3; p<0·01) reflecting greater employment, income, and long-term marital partnerships; greater trust between neighbours (–0·7, –1·2 to –0·3; p<0·01); higher levels of education (–1·9, –2·9 to –0·8; p<0·01); and increased social support (–1·1, –2·0 to –0·2; p=0·02). Factors associated with a higher risk score included difficulty accessing routine health care (2·2, 0·3 to 4·1; p=0·02), taking a prescription medication (3·5,

	Mean change in IHRS (95% CI)	p value
Community level		
Median social advantage	–1·4 (–2·5 to –0·3)	0·01
Proportion who trust neighbours*	–0·7 (–1·2 to –0·3)	0·003
Proportion with difficulty getting routine health care*	2·2 (0·3 to 4·1)	0·02
Individual level		
Completed high school or further education	–1·9 (–2·9 to –0·8)	<0·001
Taking prescription medications currently	3·5 (2·8 to 4·3)	<0·0001
Did not fill prescription because of cost	1·5 (0·5 to 2·6)	0·003
Close relationship with five or more family members	–1·1 (–2·0 to –0·2)	0·02
Male	1·8 (1·0 to 2·5)	<0·0001
Age (for 10-year change)	1·2 (0·9 to 1·5)	<0·0001

Statistically significant variables presented in the appendix (p 3) were used to create the multivariable mixed model with random intercepts for centre (n=1110). The residual total variance was 36·1, where 0·96 comes from among centres and 35·1 comes from within centre resulting in a final variance partitioning coefficient of 0·03. IHRS=INTERHEART risk score. *Effect estimates for a 10% change in the community average.

Table 6: **Overall multivariable mixed model for IHRS**

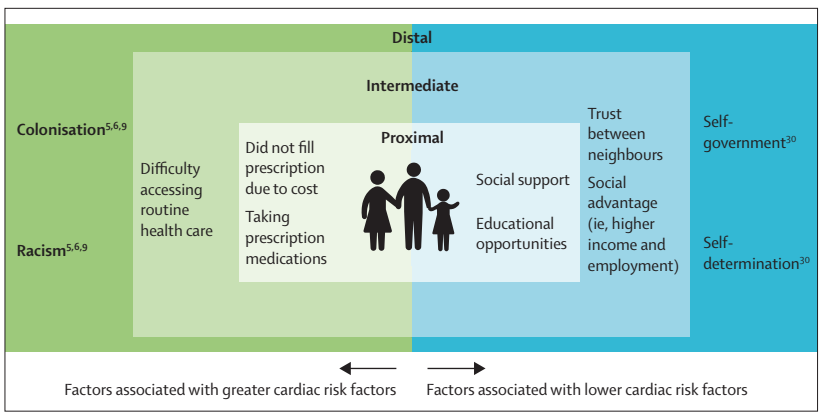

***Figure*: Distal, intermediate, and proximal factors associated with cardiac risk factor burden in First Nations communities**

The distal factors reflect historical forces, intermediate factors represent those factors identified in our analysis at the community level, and proximal are those factors we identified at the individual level to be associated with cardiac risk factor burden.

2·8 to 4·3; p<0·001), and not being able to fill the prescription medications because of cost (1·5, 0·5 to 2·6; p<0·01; table 6). Overall, 28% of variation in the IHRS was explained by these factors.

For the secondary outcome, a 1-point change in the community median IHRS was associated with a 9·3 mm³ (95% CI 0·7–17·8; p=0·03) increase in carotid wall volume, adjusted for age and sex. When each of the factors from the final multivariable model were tested versus carotid wall volume; adjusting for IHRS, age, and sex, community-level difficulty accessing routine health care remained significantly associated with carotid wall volume (p<0·01).

Discussion

The burden of cardiovascular risk factors varies significantly between First Nations communities across Canada, based on the sample of eight communities we studied. Communities that reported greater socioeconomic advantage (as evidenced by greater employment, income, and long-term marital partnerships), had greater trust between community members, a higher proportion of individuals who had completed high school education, and high social support through having many close relationships with family members had a lower burden of cardiovascular risk factors. However, communities with difficulty accessing primary care, and individuals with prescriptions for medications who could not afford prescriptions due to cost had a higher burden of risk factors. Further, difficulty accessing routine primary care and risk factor control were also associated with increased carotid atherosclerosis. Thus, greater employment opportunities, income, social support, and easier access to high-quality education and health care (including affordable medications), have the potential to contribute to better health and lower cardiovascular disease for First Nations people in Canada.

In a parallel study among non-Indigenous people in Canada (mean age 57·8 years; 55% women), the mean IHRS risk score was much lower (10·1), as was the proportion of participants who were classified as being high risk (17·6%).[15] This shows that our First Nations participants have a significantly higher burden of risk factors. Although neither study was a random population-based sample, this difference in risk factor burden was observed previously in a random comparative sample of First Nations and people of European origin living in Canada.[1] Communities and governments across all levels should make the provision of support and resources for First Nations-led solutions towards better health a priority (appendix p 2).

Understanding the reasons for variation in cardiovascular disease risk factors between First Nations communities is informative because it provides evidence that protective factors such as high socioeconomic advantage,[17] social support,[18] attaining higher education levels, and trust between neighbours are associated with lower cardiovascular risk factors. An analysis of 31625 Indigenous adults living in Canada showed that women reporting high levels of social support were more likely to report thriving health, and that social support is a key trait reflecting traditional cultural values and strength of families and communities.[19] More recently, the 2015/16 First Nations Regional Health Survey of more than 24000 First Nations people from more than 250 communities in Canada reported that adults with greater social support were more likely to engage in other healthy behaviours such as physical activity, and reported better mental, emotional, and spiritual health. This report highlighted the need for such protective aspects of the social environment to be included in any future intervention studies involving First Nations people of Canada.[19] Furthermore, our data reaffirm previous studies that have shown that increasing education level is associated with improved health outcomes,[20] and call for dedicated funding and new initiatives to support communities in reaching this goal.

Reduced access to routine health care is a significant explanatory factor for the higher burden of cardiovascular risk factors and subclinical atherosclerosis observed among communities. Reduced access to routine primary care, screening, and a trusting relationship with a primary health-care provider is directly related to whether screening for cardiovascular risk factors occurs. Previous analyses among 2138 Indigenous adults with diabetes from the USA showed that regular primary care use was associated with an 89% increased likelihood of blood pressure control and 177% increase likelihood of glycaemic control.[21] Furthermore, a scoping review of 50 previous studies of Indigenous peoples' barriers to primary care reported that not only does primary health care need to be easily accessible (which requires addressing communication and transportation barriers), it should be culturally safe and, wherever possible, locally

run by Indigenous health-care service providers.[22] The significant effect of the inability to fill prescriptions because of cost is an important issue. First Nations communities are either wholly or partially dependent on the Government of Canada to provide prescription medications without cost to the patient through the non-insured health benefits programme.[23] Possible explanations for why, in our study, 13·5% of participants reported they were unable to fill prescriptions because of cost include an expectation that clients pay for medications up front and are then reimbursed, the medications prescribed are not covered by the non-insured health benefits programme, or the process of applying for coverage is too onerous. This requires further study to assess the ease of access for prescription medications for First Nations peoples.

Our findings can help empower First Nations peoples and their research partners to advocate for change. Our data show the high risk factor burden, socioeconomic disadvantage, and reduced access to health services compared with non-Indigenous people,[11] which re-enforces the health inequities that First Nations people in Canada face (figure). Although our findings might seem unsurprising, our results emphasise the positive factors that are related to better health of First Nations peoples, offering possible solutions to the current health status of First Nations peoples. Furthermore, our findings refocus the traditional emphasis on individual change. Why, in a high-income country like Canada, do First Nations people continue to have preventable diseases at a disproportionately higher frequency than non-Indigenous people?[24] Cardiovascular risk factor control, through use of evidence-based treatments, is highly effective in lowering the burden of cardiovascular disease. Data from Ontario, Canada, show non-Indigenous people have had a steady decline in cardiovascular disease mortality over the past 20 years, due to early screening and treatment of risk factors and in hospital care.[25] Why is it that the same trends have not occurred among First Nations peoples living in reserve communities?[26] The proportion of participants in our analysis with moderate to high cardiac risk score was 85%, showing the high-risk nature of our study population. Modifying risk factors, including elevated cholesterol, diabetes, high blood pressure, smoking, stress, diet quality, and low leisure time activity has the potential to reduce the burden of cardiovascular disease by 80%.[27] Dedicated health-care professionals focused on identifying and treating cardiovascular risk factors would be a tangible step to help individuals reduce their risk, while the broader community level and health-care access factors are addressed, ideally through culturally safe and First Nations-led programmes (appendix p 2).[5,9,26,28]

We believe our study, together with previously published reports, provide strong evidence that First Nations communities face health inequity with respect to their high burden of cardiovascular risk factors and access to health services. These observations are compounded by the substantial proportion of participants who face high unemployment and lower household incomes. In addition to ensuring the basic needs of communities such as clean water, housing, education, and primary health care are met, access to affordable prescription medications is also needed. Programmes that improve the health of First Nations people will accelerate their path to self-determination.[29] The Truth and Reconciliation Commission Call to Action 5 states that "reconciliation must create a more equitable and inclusive society by closing its gaps in social, health, and economic outcomes that exist between Aboriginal and non-Aboriginal Canadians", and we strongly endorse this call to action for governments to accelerate closing of these gaps.[30]

Strengths of our study include the common protocol used in eight geographically diverse communities, the high quality of data collection and completeness (appendix p 14). Furthermore, our study is an example of a First Nations study, as opposed to assuming First Nation, Metis, and Inuit peoples are homogeneous.[8] Individuals from each community volunteered to participate in this study, and community data do not represent a random sample. To make the proportions of risk factors more comparable among communities, we adjusted each factor by age and sex. Furthermore, our study of eight communities is a small proportion of the more than 600 First Nations communities in Canada; thus, our findings might not be generalisable to all communities. However, our model predicting variations among communities remains internally valid and innovative because we summarise some of the individually collected data into community-level variables. By grouping data in this way, some information is lost in exchange for a measure that is more useful in answering our study objective.

We show that the burden of cardiovascular risk factors varies between First Nations communities across Canada. Communities with higher socioeconomic advantage and greater trust among community members, and individuals who have completed high school education or have high social support, have a lower burden of cardiac risk factors, whereas communities with difficulty accessing health care, and individuals taking prescription medications or who cannot afford prescription medications due to cost, have a greater burden of risk factors. The features that place communities and individuals at risk are probably the downstream results of colonisation and its legacy effects. Strategies to optimise health equity, economic independence, and self-determination in First Nations communities in Canada are urgently needed to improve their health and wellbeing.

Contributors

SSA contributed to all aspects of the Article. SA, LA, JB, HC, SH, JI, JL'H, LM, JM, RTO, MP, PP, and ELT contributed to conception, design, data acquisition, analysis, interpretation, and revision of the Article.

KB and KMS contributed to data analysis and interpretation, and Article revision. VC and ADD contributed to data acquisition and interpretation, and Article revision. DD, RJdS, MGF, and RL contributed to the design, data acquisition and interpretation, and Article revision. SM, IC, and Pictou Landing First Nation contributed to the design, data acquisition, and Article revision.

Declaration of interests

SSA has received consultant and speaking fees from Bayer, not related to this work. HC reports grants from Canadian Institutes of Health Research during the study. RJdS reports personal fees from WHO, Canadian Institutes of Health Research/Health Canada, and McMaster Children's Hospital; grants from Canadian Foundation for Dietetic Research, Canadian Institutes for Health Research, Hamilton Health Sciences Corporation, and Hamilton Health Sciences Corporation/Population Health Research Institute; and personal fees and non-financial support from WHO, outside the submitted work. MGF reports grants, personal fees and other (board member, consultant) from Circle Cardiovascular Imaging. outside the submitted work. SH reports grants from Sanofi, Eli Lilly, Novo Nordisk, AstraZeneca, Janssen, Merck, Abbott, Boehringer Ingleheim, JDRF, Lawson, Health Canada, and First Nations and Inuit Health Branch; and personal fees from Medtronic and Amgen, outside the submitted work. All other authors declare no competing interests.

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